SYSTEM BASED ON BISTABLE MICROELECTROMECHANICAL SYSTEM, ITS OPERATING METHOD AND ITS MANUFACTURING METHOD

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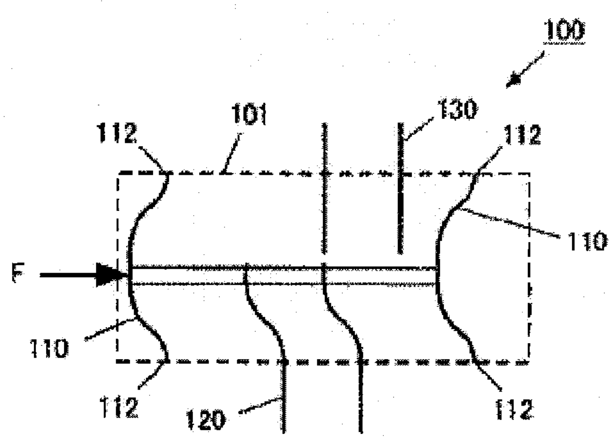
Abstract of **JP2004025437**

PROBLEM TO BE SOLVED: To improve flexibility of design and manufacturability in a bistable system.
SOLUTION: A bistable microelectromechanical system (MEMS) based system 100 comprises a micromachined beam 110 having a first stable state, in which the beam 110 is substantially stress-free and has a specified non-linear shape, and a second stable state. The curved shape of the beam 110 may comprise a simple curve or a compound curve. In embodiments, the boundary conditions 112 for the beam 110 are fixed boundary conditions, bearing boundary conditions, spring boundary conditions, or a combination thereof.



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1. **SYSTEM BASED ON BISTABLE MICROELECTROMECHANICAL SYSTEM, ITS OPERATING METHOD AND ITS MANUFACTURING METHOD**
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2. **Bistable microelectromechanical system based structures, systems and methods**
   Inventor: KUBBY JOEL A (US); YANG FUQIAN (US); (+3) **Applicant:** XEROX CORP (US)
   EC: G02B6/35D **IPC:** ***G02B26/08; B81B3/00; G02B6/35*** (+8)
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3. **Bistable microelectromechanical system based structures, systems and methods**
   Inventor: KUBBY JOEL A (US); YANG FUQIAN (US); (+3) **Applicant:** XEROX CORP (US)
   EC: G02B6/35D **IPC:** ***G02B26/08; B81B3/00; G02B6/35*** (+8)
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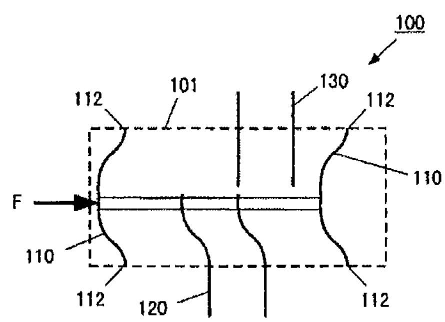
(54)【発明の名称】双安定微小電子機械システムに基づくシステム、その作動方法及びその製造方法

(57)【要約】

【課題】双安定システムにおける設計の柔軟性及び製造性を改善する。

【解決手段】微細機械加工された梁１１０であって、該梁１１０がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁１１０を含む双安定微小電子機械システム（ＭＥＭＳ）に基づくシステム１００を提供する。梁１１０の湾曲形状は、単純曲線または複合曲線を含んでもよい。実施形態において、梁１１０の境界条件１１２は、固定境界条件、ベアリング境界条件、ばね境界条件、またはこれらの境界条件を組み合わせた境界条件である。

【選択図】　図１



【特許請求の範囲】
【請求項1】
双安定微小電子機械システムに基づくシステムであって、
少なくとも１個の微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁を備えることを特徴とする双安定微小電子機械システムに基づくシステム。
【請求項2】
請求項１に記載のシステムであって、
前記少なくとも１個の梁を第１安定状態と第２安定状態の間で動かすために設けられたアクチュエータと、
前記少なくとも１個の梁の第１安定状態と第２安定状態の間の移動に従って、第１位置と第２位置の間を移動する可動素子と、
を更に備えることを特徴とするシステム。
【請求項3】
請求項１に記載の双安定微小電子機械システムに基づくシステムを用いた微小電子機械システムに基づくシステムの作動方法であって、
前記少なくとも１個の梁を第１安定状態から第２安定状態に動かす第１力を第１方向に印加するステップを含むことを特徴とする方法。
【請求項4】
請求項３に記載の方法であって、
前記少なくとも１個の梁が第２安定状態に至る前に、該少なくとも１個の梁を停止させるステップを更に含むことを特徴とする方法。
【請求項5】
請求項３に記載の方法であって、
第２力を第２方向に印加して、前記少なくとも１個の梁を第１安定状態に戻すステップを更に含むことを特徴とする方法。
【請求項6】
双安定微小電子機械システムに基づくシステムの製造方法であって、
少なくとも１個の梁であって、該梁の第１安定状態に対応する所定の非線形形状を有する梁をリソグラフィにより規定するステップを含むことを特徴とする方法。
【請求項7】
請求項６に記載の方法であって、
所定のジオメトリを有するように前記少なくとも１個の梁をリソグラフィにより規定するステップを更に含むことを特徴とする方法。
【請求項8】
請求項１に記載の双安定微小電子機械システムに基づくシステムを含む微小電子機械システムに基づくシステムであって、
入力部と、出力部と、入力部と出力部の間に設けられた可動素子と、を含み、
前記双安定微小電子機械システムは前記可動素子に隣接して設けられ、
前記可動素子は、前記少なくとも１個の梁の第１安定状態と第２安定状態の間の移動に従って、第１位置と第２位置の間を移動することを特徴とするシステム。

【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は、微小電子機械システム（ＭＥＭＳ）に基づく構造、および少なくとも１個の双安定（ｂｉｓｔａｂｌｅ）構造を含む微小電子機械システム（ＭＥＭＳ）に基づくシステムに関する。本発明は、また、このような構造およびシステムの製造方法と、微小電子機械システムに基づくシステムの作動方法と、に関する。
【０００２】
【従来の技術】

双安定梁については、微小電子機械システム(MEMS)に基づくシステムでの用途が知られている。このような双安定梁は、たとえば、デジタルデータ記憶装置、電子式スイッチング、および光学式スイッチングなどに適用されている。

【0003】

たとえば、可同調マイクロメカニカル双安定システムが、サイフ(M. T. A. Saif)によって、2000年6月発行の微小電子機械システム刊行誌第9巻、第2号、157〜170頁の「可同調双安定MEMS理論と実験(“On a Tunable Bistable MEMS − Theory andExperiment”, Journal of Microelectromechanical Systems, Vol. 9, No. 2, pp. 157−170, June 2000)、非特許文献1」に記載されている。この双安定システムは、アクチュエータに取り付けた細長いマイクロメカニカル梁で構成される。梁は、製造途中に顕現する横力、および残留応力にさらされる。アクチュエータが梁の軸方向に圧縮力を生成するため、梁は横方向に座屈して、2つの平衡状態の一方の状態に至る。

【0004】

周知の梁構造の別の例としては、バンボ(Vangbo)他による説明が、1998年刊行のマイクロメカニカル、マイクロエンジニアリング8号、29〜32頁、「横方向対称双安定座屈梁(“A Lateral Symmetrically bistable buckled beam” J. Micromech. Micreng., 8(1998))、非特許文献2」に記載されている。その記載にあるように、横方向対称双安定梁は、微小電子機械システム(MEMS)に基づく装置にスナップ止めされ、ばね力により定位置に保持される。梁構造は解放型の直立した梁を含み、該梁は、引張り応力を誘導するように酸化処理されているか、あるいは梁上に定着された圧縮被膜を備えている。

【0005】

クエンツァー(Quenzer)他に付与された米国特許第6,168,395号(特許文献1)には、空圧継手または水圧継手を用いた双安定静電アクチュエータが開示されている。この双安定アクチュエータは、封入電極によって駆動される座屈薄膜部を含む。薄膜は、1つの薄膜を下部に引くと、別の薄膜が押し上げられるというように、反作用で動作する。双安定アクチュエータは、特に、マイクロバルブへの適用を目的として設計されたもので、湾曲形状の電極を使用する。

【0006】

ヒチワ(Hichwa)他に付与された米国特許第6,303,885号(特許文献2)には、微細機械加工された双安定の電子機械式スイッチが記載されている。この双安定スイッチに含まれるスイッチ素子は、スイッチ本体部の間で複数のスプリングアームによって吊り下げられている。スプリングアームは、中央梁の中空本体部の壁に取り付けられており、該スプリングアームと中空の梁の壁は、アクチュエータの原動力に応答して安定状態の間で変形する。

【0007】

【特許文献1】

米国特許第6,168,395号明細書

【特許文献2】

米国特許第6,303,885号明細書

【非特許文献1】

サイフ、“On a Tunable Bistable MEMS− Theory and Experiment”, Journal of Microelectromechanical Systems, Vol. 9, No. 2, pp. 157−170, June 2000

【非特許文献2】

バンボ他、“A lateral Symmetrically bistable b

ｕｃｋｌｅｄ　ｂｅａｍ”　Ｊ．　Ｍｉｃｒｏｍｅｃｈ．　Ｍｉｃｒｅｎｇ．，８（１９９８），ｐｐ．２９－３２

【０００８】

【発明が解決しようとする課題】

前述したように、周知の双安定梁には、組み込み応力、印加圧縮力、または追加のばねを形成する中空梁部のいずれかが必要になる。しかしながら、印加圧縮力のためのアクチュエータを追加すると、システムの設計および製造が複雑になる。また、梁に組み込み応力を作成すると、組み込み応力の制御が困難であるために、製造が困難なものになる。更に、中空梁部を追加すると、設計および製造がますます複雑になる。したがって、本発明の目的は、従来の双安定梁に関する前述した問題点および他の障害を排除することにある。

【０００９】

【課題を解決するための手段】

本発明に係るシステムおよび方法は、微細機械加工された双安定梁であって、該梁がほとんど応力を受けない第１安定状態を有する双安定梁を提供する。

【００１０】

本発明に係るシステムおよび方法は、また別に、双安定システムの設計における柔軟性を改善する。

【００１１】

本発明に係るシステムおよび方法は、また別に、双安定システムの設計における複雑さを低減する。

【００１２】

本発明に係るシステムおよび方法は、また別に、双安定システムの製造性を改善する。

【００１３】

本発明に係るシステムおよび方法は、また別に、双安定システムの大きさおよび重さを削減する。

【００１４】

本発明に係るシステムおよび方法は、また別に、双安定システムの製造コストを削減する。

【００１５】

本発明に係るシステムおよび方法は、また別に、性能が改善された双安定作動を提供する。

【００１６】

本発明に係るシステムおよび方法は、また別に、ロバスト性と信頼性の少なくとも一方が改善された双安定作動を提供する。

【００１７】

本発明に係るシステムおよび方法は、また別に、効率が改善された双安定作動を提供する。

【００１８】

本発明に係るシステムおよび方法は、また別に、面外の剛性が向上した双安定梁を提供する。

【００１９】

本発明に係るシステムおよび方法は、また別に、非接触状態と定常状態の少なくとも一方の状態における双安定梁の非接触作動を提供する。

【００２０】

本発明に係るシステムおよび方法は、また別に、双安定システムを使用したスイッチングを提供する。

【００２１】

本発明に係るシステムおよび方法は、また別に、双安定作動を用いた導波管スイッチを提供する。

【００２２】

本発明に係るシステムおよび方法は、また別に、双安定システムを用いた減衰を提供する。

【００２３】

本発明に係るシステムおよび方法は、また別に、第１安定状態にある双安定梁の第１位置の制御を改善する。

【００２４】

本発明に係るシステムおよび方法は、また別に、第２安定状態にある双安定梁の第２位置の制御を改善する。

【００２５】

本発明に係るシステムおよび方法は、また別に、ストッパを含む双安定システムを提供する。このストッパは、双安定梁が第１安定状態と第２安定状態の間の第２安定状態に近い状態にある時に双安定梁と接触する。

【００２６】

本発明のシステムおよび方法に係る各種実施形態の例において、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁を含む。各種実施形態において、所定の非線形形状は単純曲線を含む。他の各種実施形態において、所定の非線形形状は、複合曲線、たとえば、ほぼ同一の４個の円弧など、を含む。更に別の実施形態において、所定の非線形形状は一連の線分を含む。

【００２７】

例示した各種実施形態において、梁は、少なくとも１個の固定境界条件を有する。別の各種実施形態において、梁は、少なくとも１個のベアリング境界条件を有する。別の各種実施形態において、梁は、少なくとも１個のばね境界条件を有する。梁は、また、異なる境界条件を組み合わせた条件を有していてもよい。

【００２８】

例示した各種実施形態において、本システムは、更に、梁の第１安定状態と第２安定状態の間に配設されたストッパを備える。このストッパは、梁が第１安定状態から移動する時に該ストッパにバイアスされるように、梁の第２安定状態近くに配置されていてもよい。

【００２９】

本発明のシステムおよび方法に係る各種実施形態の例において、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁と、第１安定状態と第２安定状態の間で該梁を動かすために設けられたアクチュエータと、梁の第１安定状態と第２安定状態の間の移動に従って第１位置と第２位置の間を移動する可動素子と、を含む。アクチュエータは、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータのいずれであってもよい。例示した各種実施形態において、該アクチュエータは熱衝撃アクチュエータを含み、別の各種実施形態では、該アクチュエータはジッパ式静電アクチュエータ（ｚｉｐｐｅｒｉｎｇ　ｅｌｅｃｔｒｏｓｔａｔｉｃ　ａｃｔｕａｔｏｒ）を含む。

【００３０】

本発明のシステムおよび方法についての各種実施形態の例では、第１力が第１方向に印加されると、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態を有する梁が、第１安定状態から第２安定状態に移行する。第１力の印加は、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータのいずれか１つを使用した力の印加として構成してよい。例示した各種実施形態では、第１力の印加を、熱衝撃アクチュエータを使用した力の印加として構成してよい。別の各種実施形態では、第１力の印加を、ジッパ式静電アクチュエータを使用した力の印加として構成してよい。

【００３１】

例示した各種実施形態では、第２力が第２方向に印加されると、梁が第２安定状態から第

１安定状態に移行する。第２力の印加は、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータのいずれか１つを使用した力の印加として構成してよい。別の各種実施形態では、第２力の印加を、熱衝撃アクチュエータまたはジッパ式静電アクチュエータを使用した力の印加として構成してよい。
【００３２】
本発明のシステムおよび方法に係る各種実施形態の例において、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、梁の第１安定状態に対応する所定の非線形形状を有する梁をリソグラフィにより規定することで製造する。例示した各種実施形態において、本製造方法は、更に、特定のジオメトリ（ｇｅｏｍｅｔｒｙ）になるように梁をリソグラフィにより規定することで梁の第２安定状態を決定するステップを含む。各種実施形態において、特定のジオメトリを有するように梁をリソグラフィにより規定するステップは、特定の長さ、特定の幅、特定の高さ、および特定の曲率の少なくとも１つを有するように、梁をリソグラフィにより規定するステップを含む。各種実施形態では、梁の高さが梁の幅より大きくなるように梁の高さを定義して、潜在的な梁の面外の座屈を削減する。
【００３３】
例示した各種実施形態において、本製造方法は、更に、特定のジオメトリを有するように梁をリソグラフィにより規定することで、第１安定状態と第２安定状態との間における梁の送り距離を決定するステップを含む。各種実施形態では、特定のジオメトリを有するように梁をリソグラフィにより規定するステップは、特定の長さ、特定の幅、特定の高さ、および特定の曲率の少なくとも１つを有するように梁をリソグラフィにより規定するステップを含む。
【００３４】
例示した各種実施形態において、本製造方法は、更に、特定のジオメトリを有するように梁をリソグラフィにより規定することで、第１安定状態と第２安定状態との間における梁の力曲線を決定するステップを含む。各種実施形態において、特定のジオメトリを有するように梁をリソグラフィにより規定するステップは、特定の長さ、特定の幅、特定の高さ、および特定の曲率の少なくとも１つを有するように梁をリソグラフィにより規定するステップを含む。
【００３５】
例示した各種実施形態において、本製造方法は、更に、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータの少なくとも１個を梁に隣接して形成するステップを含む。各種実施形態では、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータの少なくとも１個を梁に隣接して形成するステップは、熱衝撃アクチュエータを形成するステップを含む。他の各種実施形態では、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、および磁気アクチュエータの少なくとも１個を梁に隣接して形成するステップは、ジッパ式静電アクチュエータを形成するステップを含む。
【００３６】
例示した各種実施形態において、本製造方法は、更に、少なくとも１個の梁の固定境界条件を形成するステップを含む。別の各種実施形態において、本製造方法は、更に、少なくとも１個の梁のベアリング境界条件を形成するステップを含む。他の各種実施形態において、本製造方法は、更に、少なくとも１個の梁のばね境界条件を形成するステップを含む。本製造方法は、更に、異なる境界条件を組み合わせた梁の境界条件を形成するステップを含んでもよい。
【００３７】
例示した各種実施形態において、梁をリソグラフィ技術的に定義する製造ステップは、ＳＯＩ（ｓｉｌｉｃｏｎ－ｏｎ－ｉｎｓｕｌａｔｏｒ）ウェーハのデバイス層に梁をパターニングするステップを含む。本製造方法は、更に、デバイス層と基板の間の絶縁層を部分的にエッチングして梁を解放すると共に、絶縁層を部分的に残して梁を基板にアンカ止めするステップを含む。

【００３８】
本発明のシステムおよび方法に係る各種実施形態の例において、微小電子機械システム（ＭＥＭＳ）に基づくシステムは、入力部と、出力部と、入出力部間を繋ぐ可動素子と、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁と、を含む。例示した各種実施形態において、本システムは、光学式入出力部を備えた光学システムである。例示した別の実施形態において、本システムは、電子式入出力部を備えた電子システムである。更に別の実施形態において、本システムは、流体入出力部を備えた流体システムである。例示した各種実施形態において、本システムは、データ格納システムを含む。例示した別の実施形態において、本システムは、スイッチングシステムを含む。
【００３９】
前述した本発明の特性および利点は、本発明に係るシステムおよび方法の各種実施形態についての下記の詳細な説明から明らかになるであろう。
【００４０】
【発明の実施の形態】
本発明のシステムおよび方法についての各種実施形態について、添付の図面を参照しながら説明する。
【００４１】
本発明について、光学式スイッチングシステムを参照しながら説明するが、本発明はこのようなシステムに限定されないことは理解されるであろう。双安定状態を利用した微小電子機械システム（ＭＥＭＳ）に基づくシステムは、本発明の対象となる。下記の説明は、本発明の特徴を示すためのものであり、開示した特定の実施形態に本発明を限定するものではない。
【００４２】
本発明に係るシステムおよび方法は、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムを提供する。本発明の各種実施形態において、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁を含む。本発明に係る双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、設計における柔軟性の向上と、製造性の改善と、サイズおよび重量の削減と、製造コストの削減を提供すると共に、性能が改善された双安定作動と効率が改善された双安定作動の少なくとも一方を提供する。
【００４３】
例示した各種実施形態において、所定の非線形形状は単純曲線を含む。別の各種実施形態において、所定の非線形形状は複合曲線を含む。複合曲線は、たとえば、ほぼ同一の４つの円弧を含んでもよい。更に別の実施形態において、所定の非線形形状は一連の線分を含む。所定の非線形形状は、梁の第１安定状態を規定する。
【００４４】
例示した各種実施形態において、双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、梁の第１安定状態に対応する所定の非線形形状になるように梁をリソグラフィにより規定するステップを含む。例示した各種実施形態において、梁の第２安定状態は、所定のジオメトリ、たとえば、所定の長さ、幅、曲率の少なくとも１つを有するように梁をリソグラフィにより規定することで求める。更に、特定のジオメトリになるように梁をリソグラフィにより規定することで、梁の別の特性を決定してもよい。リソグラフィは、応力を発生させない、正確かつ制御可能な製造工程を提供する。
【００４５】
例示した各種実施形態において、梁をリソグラフィにより規定する方法は、ＳＯＩ（ｓｉｌｉｃｏｎ－ｏｎ－ｉｎｓｕｌａｔｏｒ）ウェーハのデバイス層に梁をパターニングするステップを含む。本製造方法は、更に、デバイス層と基板の間の絶縁層を部分的にエッチングして、梁を解放すると共に、絶縁層の一部を残して、基板に梁をアンカ止めするステ

ップを含む。デバイス層は、ほとんど応力を受けない層であるため、梁内から不要な応力を排除できる。
【００４６】
本発明に係るシステムおよび方法は、また、双安定作動を提供する。例示した各種実施形態において、第１力が第１方向に印加されると、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態を有する梁が、第１安定状態から第２安定状態に移行する。例示した各種実施形態において、第２力が第２方向に印加されると、梁は第２安定状態から第１安定状態に移行する。
【００４７】
本発明に係る梁と双安定作動の少なくとも一方は、各種の用途に適用してもよく、また、大規模システムの一部を形成してもよい。たとえば、微小電子機械システム（ＭＥＭＳ）に基づくシステムは、入力部と、出力部と、入出力部間を繋ぐ可動素子と、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁と、を含む。更に、本システムは光学システム、電子システム、または流体システムのいずれであってもよい。また、本システムは、データ格納システムまたはスイッチングシステムであってもよい。
【００４８】
例示した本発明の各種実施形態によれば、微細機械加工技術および他のマイクロメカニカルシステムに基づく製造技術は、微細機械加工された梁であって、該梁がほとんど応力を受けず所定の非線形形状を呈する第１安定状態と、第２安定状態と、を有する梁を加工するのに使用される。このような加工技術は、他の可能な技術と比べて比較的進んだもので、より信頼性の高い結果とより高度な柔軟性をもたらす。例示した各種実施形態では、表面微細加工技法、たとえば、前述したリソグラフィなどを利用して双安定梁を製造する。
【００４９】
本発明の第１実施形態に係る微小電子機械システム（ＭＥＭＳ）に基づくシステム１００の概略図を図１に示す。本システム１００は、図に第１安定状態で示した、１組の双安定梁１１０を含む。１組の双安定梁を図示してあるが、単一の双安定梁を用いてもよいことは理解できるであろう。２個以上の双安定梁を採用すると、梁が協調して機能するため、性能、信頼性、精度の少なくとも１つが向上する。双安定梁１１０は、適切な境界条件１１２、たとえば、固定境界条件、ベアリング境界条件、ばね境界条件、または異なる境界条件を組み合わせた境界条件を使用して基板１０１にアンカ止めされる。双安定梁１１０は、第１安定状態において、所定の非線形形状になり、ほとんど応力を受けない状態が達成されるように製造される。
【００５０】
可動メンバ１２０、たとえば、導波管、光ファイバなどを設けて、可動メンバ１２０が双安定梁１１０と共に動くように構成してもよい。図１に示すように、導波管、光ファイバなどに対応する定常状態メンバ１３０は基板１０１に固定される。
【００５１】
第１実施形態の概略図を図２に示す。図には、第２安定状態にある双安定梁１１０を示した。図示したように、可動メンバ１２０は、双安定梁１１０と共に第１安定状態から第２安定状態に移動し、定常状態メンバ１３０と整列または連結される。図１および図２に示したように、双安定梁１１０に力Ｆを印加すると、双安定梁１１０が第１安定状態と第２安定状態の間を移動する。
【００５２】
図１および図２に、双安定梁１１０を概略図で示した。梁の所定の非線形形状には、単純曲線、複合曲線、一連の線分などを含む適切な形状を用いてよいが、これらの形状に限定されるものではない。このように、所定の非線形形状は、第１安定状態を規定できる任意の形状でよい。
【００５３】
本発明の第２実施形態に係る微小電子機械システム（ＭＥＭＳ）に基づくシステム２００

の概略図を図３に示す。本システム２００は、第１安定状態で図示した１組の双安定梁２１０と、少なくとも１個のアクチュエータ２４０と、を含む。双安定梁２１０は、適切な境界条件２１２を用いて基板２０１にアンカ止めされる。

【００５４】

可動メンバ２２０を配設して、可動メンバ２２０が双安定梁２１０と共に動くように構成する。可動メンバ２２０は、アクチュエータ２４０によって双安定梁と共に第１安定状態から第２安定状態に移行する。アクチュエータ２４０が双安定梁２１０に印加する力によって、双安定梁２１０は第１安定状態と第２安定状態の間を移動する。この力については、直接的あるいは間接的に印加してもよく、また、双安定梁２１０との接触によって実現しても、あるいは双安定梁２１０と接触せずに実現してもよい。

【００５５】

アクチュエータ２４０は、既に周知の装置、あるいは今後開発される装置のいずれであっても、双安定梁を安定状態の間で動かす力を印加できる装置であればよい。アクチュエータ２４０は、たとえば、熱アクチュエータ、静電アクチュエータ、圧電アクチュエータ、磁気アクチュエータのいずれであっても、またはその任意の組み合わせであってもよい。適用する具体的な対象は、所定の用途に応じた設計考慮事項に基づいて選択してよい。たとえば、特定の用途では、熱衝撃アクチュエータまたはジッパ式静電アクチュエータが便利な場合もある。

【００５６】

前述したように、本発明に係る微小電子機械システム（ＭＥＭＳ）に基づくシステムは、大規模システム、または複合システムに組み込んでよい。たとえば、図４に概略を示したように、光学式スイッチングシステム３００は、１組の双安定梁３１０を含む。双安定梁３１０は、図において、所定の非線形形状を呈する、ほとんど応力を受けない第１安定状態で示されている。

【００５７】

本システム３００が更に備える入力光ファイバ３５０と出力光ファイバ３６０は、それぞれ、異なる定常状態の導波管３３２，３３４と繋がるように配設される。可動スイッチングメンバ３２０は、定常状態導波管３３２と３３４の間に位置しており、該定常状態導波管３３２，３３４に対して相対的に移動できる。可動スイッチングメンバ３２０を配設して、双安定梁３１０と共に動くように構成する。可動スイッチングメンバ３２０は、図４に示すように、たとえば、導波管３２２の配列を備えていてもよい。

【００５８】

使用において、アクチュエータ（図示せず）によって力Ｆが双安定梁３１０に印加されると、双安定梁３１０は、図４に示した第１安定状態から第２安定状態（図示せず）に移行する。可動スイッチングメンバ３２０が双安定梁３１０と共に移動することによって、別の導波管３２２が定常状態導波管３３２と３３４の間を繋ぐ。この方法では、入力光ファイバ３５０の一方への光信号の入力は、たとえば、出力光ファイバ３６０の間で切り換えてもよい。また、可動メンバ３２０の導波管３２２を配設して、第１安定状態と第２安定状態の間における双安定梁３１０の移動に合わせて可動メンバ３２０を動かすことによって光信号を切り換えてもよい。更に、可動メンバ３２０の導波管３２２は、光信号を減衰させるように設けられていてもよい。

【００５９】

図４に示すように、第２安定状態は、ストッパ３７０を挿入することで変更してもよい。ストッパ３７０は、双安定梁３１０の一方が、本来の第２安定状態に達する前にストッパ３７０と接触するように配置される。ストッパ３７０をこのように配置すると、双安定梁３１０の一方が、第２安定状態においてストッパ３７０にバイアスされる。この状態は、双安定梁３１０および可動メンバ３２０が、正確かつ確実に第２安定状態に至るように補助する。図４に示すように、ストッパ３７０に隆起３７２を設け、接触状態にある双安定梁３１０の一部とストッパ３７０の間の静摩擦を抑制してもよい。

【００６０】

図５に例示したグラフは、梁を動かすために印加する力と、該力に対する梁の変位を示している。梁の非線形形状およびジオメトリが実際の曲線を決定する。
【００６１】
第１安定状態から移動した後、梁は、不安定な均衡状態を通過して、安定した均衡状態である梁の第２安定状態に移行する。ストッパ３７０の位置は、図５の中に仮想点線で示した。図示したように、ストッパは、不安定な均衡状態と、本来の第２安定状態に該当する安定した均衡状態の間における約０．０１８５ｍｍの位置に設けられている。したがって、梁は、本来の第２安定状態に該当する安定した均衡状態に至る前に停止することになる。この安定した均衡状態へと向かう梁の復元力により梁がストッパにバイアスされる。
【００６２】
双安定微小電子機械システム（ＭＥＭＳ）に基づくシステムは、本発明に従って、梁の第１安定状態に対応する所定の非線形形状を備える梁をリソグラフィにより規定することで製造してもよい。リソグラフィ技術としては、周知、または今後開発される任意のリソグラフィ技術を利用してよい。リソグラフィによって、梁の特性、たとえば、形状およびジオメトリなどを正確に製造できる。
【００６３】
前述したように、梁の所定の非線形形状は、該梁の第１安定状態を規定する。同様に梁のジオメトリは、該梁の第２安定状態を規定する。したがって、本発明の各種実施形態によれば、本製造方法は、更に、所定のジオメトリを有するように梁をリソグラフィにより規定することで、梁の第２安定状態を決定するステップを含む。所定のジオメトリは、所定の長さ、所定の幅、および所定の曲率の少なくとも１つまたは複数を含んでよい。高さは、梁が作成される材料層の厚さによって規定してもよいことは理解されるであろう。
【００６４】
また、梁の所定のジオメトリをリソグラフィにより規定して、梁の他の各種特性を規定してもよい。たとえば、梁の送り距離と力曲線の少なくとも一方を規定するように、梁のジオメトリを規定してもよい。
【００６５】
例示した各種実施形態では、リソグラフィを用いて、双安定梁に関連付けるアクチュエータを形成している。同様に、双安定梁の境界条件も、リソグラフィ技法を用いて形成してよい。また、他の同様の製造技術を使用してもよいが、システム全体を同一の技法で製造すると、たとえば、独立した方法ステップを減らして、行程を単純にできる点で有利である。
【００６６】
前述したように、梁は、ＳＯＩウェーハのデバイス層内で梁をパターニングして、リソグラフィにより規定してもよい。デバイス層と基板の間の絶縁層を部分的にエッチングして、梁を解放すると共に、絶縁層の一部を残して基板に梁をアンカ止めする。梁をアンカ止めする絶縁層部分は、所望の境界条件を梁に規定するようにパターニングおよびエッチングする。
【００６７】
デバイス層内での双安定梁の製造に適した技法の例は、参照用に全体をそのまま援用する同時係属中の米国特許出願第０９／４６７，５２６号、第０９／４６８，４２３号、および第０９／４６８，１４１号に記載されている。別の適切な技術は、参照用に全体をそのまま援用する同時係属中の米国特許出願第０９／７１８，０１７号に記載されている。
【００６８】
一般に、ポリシリコン表面の微細機械加工では、プレーナー製造工程のステップを利用する。このステップは、微小電子機械装置およびマイクロメカニカル装置を製造する集積回路（ＩＣ）製造産業に共通したステップである。標準的なブロック組み立て工程は、基板上に代替層を成膜してフォトリソグラフィ技術でパターニングするステップを含む。代替層は、応力の低い多結晶シリコンと、たとえば基板上の二酸化ケイ素のような犠牲層と、を含む。犠牲層を通じてエッチングされたビアは、多結晶シリコン層間および基板にアン

力点を提供する。多結晶シリコン層をパターニングして、微細機械加工装置のメカニカル素子を形成する。メカニカル素子は、このように、蒸着工程およびパターニング工程の一連のステップで層ごとに形成される。二酸化ケイ素層は、その後、多結晶シリコン層に付着しない選択的エッチング液、たとえば、フッ化水素酸（ＨＦ）などに晒すことによって除去される。これにより、多結晶シリコン層に形成されたメカニカル素子が解放され、メカニカル素子の動作が可能になる。

【００６９】
本発明について、各種実施形態を参照しながら説明したが、各種の置き換え、修正、変更が可能であることは、当業者であれば理解されるであろう。したがって、本発明の精神および範囲にそれることのない置き換え、修正、および変更は、すべて、本発明の範囲に包含されるものである。

【図面の簡単な説明】

【図１】本発明に係る双安定梁を含む、微小電子機械システム（ＭＥＭＳ）の第１実施形態の概略図である。

【図２】図１の第１実施形態を第２安定状態で示した概略図である。

【図３】本発明に係る双安定梁とアクチュエータを含む、微小電子機械システム（ＭＥＭＳ）の第２実施形態の概略図である。

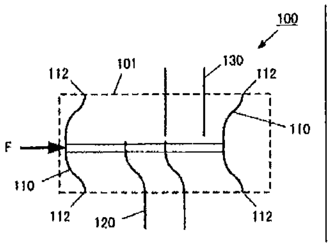
【図４】本発明に係る双安定梁を含む光学式スイッチングシステムの実施形態を第１安定状態で示した概略図である。

【図５】第２安定状態の安定した均衡状態にある図４の実施形態の力曲線を表したグラフである。

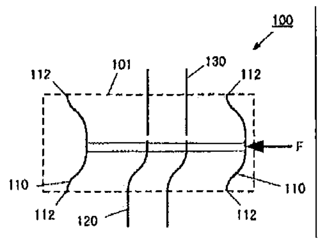
【符号の説明】

１００，２００，３００　微小電子機械システム（ＭＥＭＳ）に基づくシステム、１０１，２０１　基板、１１０，２１０，３１０　双安定梁、１１２，２１２　境界条件、１３０　定常状態メンバ、２４０　アクチュエータ、３００　光学式スイッチングシステム、３２０　可動メンバ、３３２，３３４　導波管、３５０　入力光ファイバ、３６０　出力光ファイバ、３７０　ストッパ。

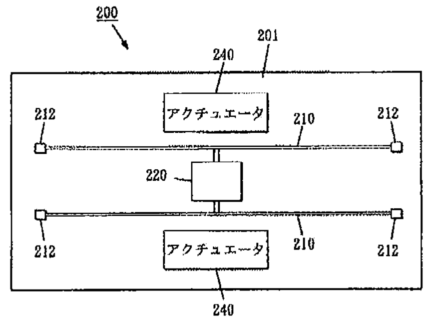
【図1】


100
101
130
112
110
F
120

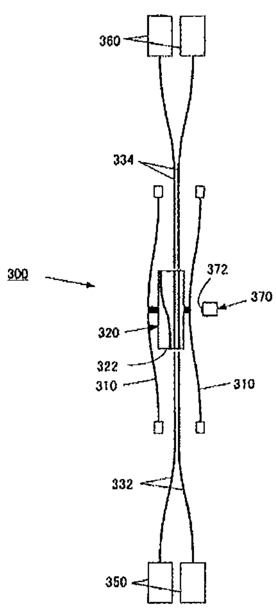
【図2】


100
101
130
112
110
F
120

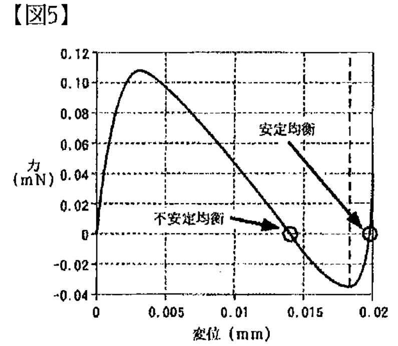
【図3】


200
201
240
アクチュエータ
212
210
220
アクチュエータ
240

【図4】


360
334
300
372
370
320
322
310
310
332
350

【図5】


力
(mN)
安定均衡
不安定均衡
変位 (mm)
0.12
0.10
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
0.005
0.01
0.015
0.02

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Ｆターム(参考) 2H041 AA14　AA18　AB19　AC01

CLAIMS

[Claim(s)]
[Claim 1]
It is a system based on a bistability minute electronic mechanical system,
The system based on the bistability minute electronic mechanical system which is at least one beam by which detailed machining was carried out, and is characterized by having the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state.
[Claim 2]
It is a system according to claim 1,
The actuator formed in order to move said at least one beam between the 1st stable state and the 2nd stable state,
The movable component which moves between the 1st location and the 2nd location according to migration between the 1st stable state of said at least one beam, and the 2nd stable state,
Furthermore, the system characterized by having.
[Claim 3]
It is the actuation approach of a system based on the minute electronic mechanical system using the system based on a bistability minute electronic mechanical system according to claim 1,
The approach characterized by including the step which impresses the 1st force of moving said at least one beam from the 1st stable state to the 2nd stable state in the 1st direction.
[Claim 4]
It is an approach according to claim 3,
The approach characterized by including further the step which stops one beam even if this ** cannot be found before said at least one beam results in the 2nd stable state.
[Claim 5]
It is an approach according to claim 3,
The approach characterized by impressing the 2nd force in the 2nd direction and including further the step which returns said at least one beam to the 1st stable state.
[Claim 6]
It is the manufacture approach of a system based on a bistability minute electronic mechanical system,
The approach which is at least one beam and is characterized by including the step which specifies with lithography the beam which has a predetermined nonlinear configuration corresponding to the 1st stable state of this beam.
[Claim 7]
It is an approach according to claim 6,
The approach characterized by including further the step which prescribes with lithography that said at least one beam has predetermined geometry.
[Claim 8]
It is a system based on the minute electronic mechanical system containing the system based on a

bistability minute electronic mechanical system according to claim 1,
The movable component prepared between the input section, the output section, and the input section and the output section is included,
Said bistability minute electronic mechanical system adjoins said movable component, and is formed,
Said movable component is a system characterized by moving between the 1st location and the 2nd location according to migration between the 1st stable state of said at least one beam, and the 2nd stable state.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
This invention relates to the system based on a minute electronic mechanical system (MEMS) including the structure based on a minute electronic mechanical system (MEMS), and at least one bistability (bistable) structure. This invention relates to such a manufacture approach of structure and a system, and the actuation approach of a system based on a minute electronic mechanical system again.
[0002]
[Description of the Prior Art]
About the bistability beam, the application in the system based on a minute electronic mechanical system (MEMS) is known. Such a bistability beam is applied to a digital data storage, electronic formula switching, optical switching, etc.
[0003]
for example, the minute electronic mechanical-system publication magazine of the June, 2000 issuance of a good alignment micro mechanical bistability system by SAIFU (M. T.A.Saif) -- it is indicated by the 9th volume, No. 2, and 157-170-page "the good alignment bistability MEMS theory, an experiment ("On a Tunable Bistable MEMS-Theory andExperiment", Journal of Microelectromechanical Systems, Vol.9, No.2, pp.157-170, and June 2000) and nonpatent literature 1." This bistability system consists of long and slender micro mechanical beams attached in the actuator. A beam is exposed to the lateral force which manifests itself in the middle of manufacture, and residual stress. In order that an actuator may generate compressive force to the shaft orientations of a beam, a beam is buckled in a longitudinal direction and results in one condition of two equilibrium.
[0004]
Explanation [/ else / BAMBO / (Vangbo)] is indicated by the micro mechanical of publication, the micro engineering No. 8, 29-32 pages, and "a longitudinal direction symmetry bistability buckling beam ("A Lateral Symmetrically bistable buckled beam" J.Micromech.Micreng., 8 (1998)) and nonpatent literature 2" as another example of well-known beam structure in 1998. As it is in the publication, the snap stop of the longitudinal direction symmetry bistability beam is carried out to the equipment based on a minute electronic mechanical system (MEMS), and it is held in an orientation according to the spring force. This beam is equipped with the compression coat to which it is oxidized so that tensile stress may be guided, or it was fixed on the beam including the beam on which, as for beam structure, the release mold stood straight.
[0005]
The bistability electrostatic actuator which used the pneumatics joint or the water pressure joint is indicated by U.S. Pat. No. 6,168,395 (patent reference 1) given to KUENTSUA (Quenzer) etc. This bistability actuator contains the buckling thin film section driven with an enclosure electrode. A thin film operates by reaction as another thin film will be pushed up, if one thin film is lengthened in the lower part. Especially the bistability actuator was designed for the purpose of application on a micro

bulb, and the electrode of a bow configuration is used for it.

[0006]

The electronic mechanical-cable-type switch of bistability by which detailed machining was carried out is indicated by U.S. Pat. No. 6,303,885 (patent reference 2) given to HICHIWA (Hichwa) etc. The switching device contained in this bistability switch is hung by two or more spring arms between the switch body sections. The spring arm is attached in the wall of the hollow body section of a central beam, and the wall of this spring arm and a beam in the air answers the motive power of an actuator, and deforms between stable states.

[0007]

[Patent reference 1]

U.S. Pat. No. 6,168,395 description

[Patent reference 2]

U.S. Pat. No. 6,303,885 description

[Nonpatent literature 1]

SAIFU, "On a Tunable Bistable MEMS-Theory and Experiment", Journal of Microelectromechanical Systems, Vol.9, No.2, pp.157-170, and June 2000

[Nonpatent literature 2]

"A lateral Symmetrically bistable buckled beam" J.Micromech.[besides BAMBO] Micreng., 8 (1998), pp.29-32

[0008]

[Problem(s) to be Solved by the Invention]

As mentioned above, either of the hollow **** which form inclusion stress, impression compressive force, or an additional spring is needed for a well-known bistability beam. However, if the actuator for impression compressive force is added, a design and manufacture of a system will become complicated. Moreover, if it includes in a beam and stress is created, since control of inclusion stress is difficult, manufacture will become difficult. Furthermore, if hollow **** is added, a design and manufacture will become still more complicated. Therefore, the object of this invention is to eliminate the conventional trouble and other conventional failures about a bistability beam which were mentioned above.

[0009]

[Means for Solving the Problem]

The system and approach concerning this invention are the bistability beam by which detailed machining was carried out, and offer the bistability beam which has the 1st stable state from which this beam hardly receives stress.

[0010]

The system and approach concerning this invention improve the flexibility in the design of a bistability system independently again.

[0011]

The system and approach concerning this invention reduce the complexity in the design of a bistability system independently again.

[0012]

The system and approach concerning this invention improve the manufacturability of a bistability system independently again.

[0013]

The system and approach concerning this invention reduce a bistability system size and weight independently again.

[0014]

The system and approach concerning this invention reduce the manufacturing cost of a bistability system independently again.

[0015]

The system and approach concerning this invention offer independently the bistability actuation by which the engine performance has been improved again.

[0016]
The system and approach concerning this invention offer independently the bistability actuation by which at least one side of robustness and dependability has been improved again.
[0017]
The system and approach concerning this invention offer independently the bistability actuation by which effectiveness has been improved again.
[0018]
The system and approach concerning this invention offer independently the bistability beam whose rigidity outside a field improved again.
[0019]
The system and approach concerning this invention offer non-contact actuation of the bistability beam in one [at least] condition of a non-contact condition and a steady state independently again.
[0020]
The system and approach concerning this invention offer independently the switching which used the bistability system again.
[0021]
The system and approach concerning this invention offer the waveguide switch using bistability actuation independently again.
[0022]
The system and approach concerning this invention offer the attenuation using a bistability system independently again.
[0023]
The system and approach concerning this invention improve control of the 1st location of the bistability beam in the 1st stable state independently again.
[0024]
The system and approach concerning this invention improve control of the 2nd location of the bistability beam in the 2nd stable state independently again.
[0025]
The system and approach concerning this invention offer the bistability system containing a stopper independently again. This stopper contacts a bistability beam, when a bistability beam is in the condition near the 2nd stable state between the 1st stable state and the 2nd stable state.
[0026]
In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is the beam by which detailed machining was carried out, and contains the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. In various operation gestalten, a predetermined nonlinear configuration contains a simple curve. In other various operation gestalten, a predetermined nonlinear configuration contains a compound curve, for example, four almost same radii etc. Furthermore, in another operation gestalt, a predetermined nonlinear configuration includes a series of segments.
[0027]
In the illustrated various operation gestalten, a beam has at least one fixed boundary condition. In another, various operation gestalten, a beam has at least one bearing boundary condition. In another, various operation gestalten, a beam has at least one spring boundary condition. The beam may have the conditions which combined different boundary condition again.
[0028]
In the illustrated various operation gestalten, this system is further equipped with the stopper arranged between the 1st stable state of a beam, and the 2nd stable state. When a beam moves from the 1st stable state, this stopper may be arranged near the 2nd stable state of a beam so that bias may be carried out to this stopper.
[0029]

In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) The 1st stable state in which this beam hardly receives stress but which it is the beam by which detailed machining was carried out, and it presents a predetermined nonlinear configuration, The beam which has the 2nd stable state, the actuator formed in order to move this beam between the 1st stable state and the 2nd stable state, and the movable component which moves between the 1st location and the 2nd location according to migration between the 1st stable state of a beam and the 2nd stable state are included. Actuators may be any of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator. In this actuator, in the illustrated various operation gestalten, this actuator contains a zipper type electrostatic actuator (zippering electrostatic actuator) with another, various operation gestalten including a thermal shock actuator.

[0030]

In the example of the various operation gestalten about the system and approach of this invention, if the 1st force is impressed in the 1st direction, it will be the beam by which detailed machining was carried out, and the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration will shift to the 2nd stable state from the 1st stable state. Impression of the 1st force may be constituted as impression of the force which used any one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and the magnetic actuators. Impression of the 1st force may consist of illustrated various operation gestalten as impression of the force which used the thermal shock actuator. Impression of the 1st force may consist of another, various operation gestalten as impression of the force which used the zipper type electrostatic actuator.

[0031]

With the illustrated various operation gestalten, if the 2nd force is impressed in the 2nd direction, a beam will shift to the 1st stable state from the 2nd stable state. Impression of the 2nd force may be constituted as impression of the force which used any one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and the magnetic actuators. Impression of the 2nd force may consist of another, various operation gestalten as impression of the force which used the thermal shock actuator or the zipper type electrostatic actuator.

[0032]

In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is manufactured by specifying with lithography the beam which has a predetermined nonlinear configuration corresponding to the 1st stable state of a beam. In the illustrated various operation gestalten, this manufacture approach contains the step which determines the 2nd stable state of a beam by prescribing with lithography that a beam becomes further specific geometry (geometry). In various operation gestalten, the step which prescribes with lithography that a beam has specific geometry contains the step which specifies a beam with lithography so that it may have at least one of specific die length, specific width of face, specific height, and the specific curvatures. With various operation gestalten, the height of a beam is defined as the height of a beam becoming larger than the width of face of a beam, and the bucklings outside the field of a potential beam are reduced.

[0033]

In the illustrated various operation gestalten, this manufacture approach is prescribing with lithography that a beam has further specific geometry, and contains the step which determines the delivery distance of the beam between the 1st stable state and the 2nd stable state. With various operation gestalten, the step which prescribes with lithography that a beam has specific geometry contains the step which prescribes with lithography that a beam has at least one of specific die length, specific width of face, specific height, and the specific curvatures.

[0034]

In the illustrated various operation gestalten, this manufacture approach is prescribing with lithography that a beam has further specific geometry, and contains the step which determines the force curve of the beam between the 1st stable state and the 2nd stable state. In various operation gestalten, the step which

prescribes with lithography that a beam has specific geometry contains the step which prescribes with lithography that a beam has at least one of specific die length, specific width of face, specific height, and the specific curvatures.
[0035]
In the illustrated various operation gestalten, this manufacture approach contains further the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator. With various operation gestalten, the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator contains the step which forms a thermal shock actuator. With other various operation gestalten, the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator contains the step which forms a zipper type electrostatic actuator.
[0036]
In the illustrated various operation gestalten, this manufacture approach contains further the step which forms the fixed boundary condition of at least one beam. In another, various operation gestalten, this manufacture approach contains further the step which forms the bearing boundary condition of at least one beam. In other various operation gestalten, this manufacture approach contains further the step which forms the spring boundary condition of at least one beam. This manufacture approach may also contain the step which forms the boundary condition of the beam which combined different boundary condition further.
[0037]
In the illustrated various operation gestalten, the manufacture step which defines a beam as a lithography technical target contains the step which carries out patterning of the beam to the device layer of a SOI (silicon-on-insulator) wafer. This manufacture approach contains the step which leaves an insulating layer selectively and carries out the support stop of the beam to a substrate while it etches a device layer and the insulating layer between substrates selectively and releases a beam further.
[0038]
the systems based on a minute electronic mechanical system (MEMS) be the input section , the output section , the movable component that connect between the I/O sections , and the beam detailed machining be carried out by the beam , and contain the beam which have the 1st stable state in which this beam hardly receive stress but , which it present a predetermined nonlinear configuration , and the 2nd stable state in the example of the various operation gestalten concerning the system and the approach of this invention . In the illustrated various operation gestalten, this system is an optical system equipped with the optical I/O section. In illustrated another operation gestalt, this system is the electronic system equipped with the electronic formula I/O section. Furthermore, in another operation gestalt, this system is a hydraulic system equipped with the fluid I/O section. In the illustrated various operation gestalten, this system contains a data storage system. In illustrated another operation gestalt, this system contains a switching system.
[0039]
The property and advantage of this invention which were mentioned above will become clear from detailed explanation of the following about the system concerning this invention, and the various operation gestalten of an approach.
[0040]
[Embodiment of the Invention]
The various operation gestalten about the system and approach of this invention are explained referring to an attached drawing.
[0041]
Although this invention is explained referring to an optical switching system, it will be understood that this invention is not limited to such a system. The system based on the minute electronic mechanical system (MEMS) using a bistable state is set as the object of this invention. The following explanation is to show the description of this invention, and does not limit this invention to the indicated specific

operation gestalt.

[0042]

The system and approach concerning this invention offer the system based on a bistability minute electronic mechanical system (MEMS). In the various operation gestalten of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is the beam by which detailed machining was carried out, and contains the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. The system based on the bistability minute electronic mechanical system (MEMS) concerning this invention offers at least one side of the bistability actuation by which the engine performance has been improved, and the bistability actuation by which effectiveness has been improved while offering improvement in the flexibility in a design, an improvement of manufacturability, the cutback of size and weight, and the cutback of a manufacturing cost.

[0043]

In the illustrated various operation gestalten, a predetermined nonlinear configuration contains a simple curve. In another, various operation gestalten, a predetermined nonlinear configuration contains a compound curve. A compound curve may also contain four for example almost same radii. Furthermore, in another operation gestalt, a predetermined nonlinear configuration includes a series of segments. A predetermined nonlinear configuration specifies the 1st stable state of a beam.

[0044]

In the illustrated various operation gestalten, the system based on a bistability minute electronic mechanical system (MEMS) contains the step which prescribes with lithography that a beam becomes a predetermined nonlinear configuration corresponding to the 1st stable state of a beam. In the illustrated various operation gestalten, the 2nd stable state of a beam is searched for by prescribing with lithography that a beam has at least one of predetermined geometry, for example, predetermined die length, width of face, and the curvatures. Furthermore, another property of a beam may be determined by prescribing with lithography that a beam becomes specific geometry. Lithography offers the accuracy and the controllable production process which do not generate stress.

[0045]

In the illustrated various operation gestalten, the method of specifying a beam with lithography contains the step which carries out patterning of the beam to the device layer of a SOI (silicon-on-insulator) wafer. This manufacture approach leaves a part of insulating layer, and contains the step which carries out the support stop of the beam to a substrate while it etches a device layer and the insulating layer between substrates selectively and releases a beam further. Since most device layers are layers which do not receive stress, they can eliminate unnecessary stress out of a beam.

[0046]

The system and approach concerning this invention offer bistability actuation again. In the illustrated various operation gestalten, if the 1st force is impressed in the 1st direction, it will be the beam by which detailed machining was carried out, and the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration will shift to the 2nd stable state from the 1st stable state. In the illustrated various operation gestalten, if the 2nd force is impressed in the 2nd direction, a beam will shift to the 1st stable state from the 2nd stable state.

[0047]

At least one side of the beam concerning this invention and bistability actuation may be applied to various kinds of applications, and may form some large systems. For example, the systems based on a minute electronic mechanical system (MEMS) are the input section, the output section, the movable component that connects between the I/O sections, and the beam by which detailed machining was carried out, and contain the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. Furthermore, these systems may be any of an optical system, electronic system, or a hydraulic system. Moreover, this system may be a data storage system or a switching system.

[0048]

According to the various operation gestalten of illustrated this invention, a detailed machining technique and the manufacturing technology based on other micro mechanical systems are the beams by which detailed machining was carried out, and are used for processing the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. Such a processing technique progressed comparatively compared with other possible techniques, and brings about a more reliable result and more advanced flexibility. With the illustrated various operation gestalten, a bistability beam is manufactured using surface micro-processing technique, for example, the lithography mentioned above.
[0049]
The schematic diagram of the system 100 based on the minute electronic mechanical system (MEMS) concerning the 1st operation gestalt of this invention is shown in drawing 1 . This system 100 contains 1 set of bistability beams 110 shown in drawing according to the 1st stable state. Although 1 set of bistability beams are illustrated, it could be understood that a single bistability beam may be used. If two or more bistability beams are adopted, since a beam will function in cooperation, at least one of the engine performance, dependability, and the precision improves. The support stop of the bistability beam 110 is carried out to a substrate 101 using the boundary condition which combined the suitable boundary condition 112, for example, fixed boundary condition, bearing boundary condition, spring boundary condition, or different boundary condition. In the 1st stable state, the bistability beam 110 becomes a predetermined nonlinear configuration, and it is manufactured so that the condition of hardly receiving stress may be attained.
[0050]
The movable member 120, for example, a waveguide, an optical fiber, etc. may be prepared, and you may constitute so that the movable member 120 may move with the bistability beam 110. As shown in drawing 1 , the steady state member 130 corresponding to a waveguide, an optical fiber, etc. is fixed to a substrate 101.
[0051]
The schematic diagram of the 1st operation gestalt is shown in drawing 2 . The bistability beam 110 in the 2nd stable state was shown in drawing. As illustrated, the movable member 120 moves to the 2nd stable state from the 1st stable state with the bistability beam 110, and is aligned or connected with the steady state member 130. If Force F is impressed to the bistability beam 110 as shown in drawing 1 and drawing 2 , the bistability beam 110 will move between the 1st stable state and the 2nd stable state.
[0052]
The schematic diagram showed the bistability beam 110 to drawing 1 and drawing 2 . Although a suitable configuration including a simple curve, a compound curve, a series of segments, etc. may be used for the predetermined nonlinear configuration of a beam, it is not limited to these configurations. Thus, a predetermined nonlinear configuration is good in the configuration of arbitration where the 1st stable state can be specified.
[0053]
The schematic diagram of the system 200 based on the minute electronic mechanical system (MEMS) concerning the 2nd operation gestalt of this invention is shown in drawing 3 . This system 200 contains 1 set of bistability beams 210 illustrated by the 1st stable state, and at least one actuator 240. The support stop of the bistability beam 210 is carried out to a substrate 201 using the suitable boundary condition 212.
[0054]
The movable member 220 is arranged, and it constitutes so that the movable member 220 may move with the bistability beam 210. The movable member 220 shifts to the 2nd stable state from the 1st stable state with a bistability beam with an actuator 240. According to the force which an actuator 240 impresses to the bistability beam 210, the bistability beam 210 moves between the 1st stable state and the 2nd stable state. About this force, even if you may impress directly or indirectly and contact on the bistability beam 210 realizes, you may realize, without contacting the bistability beam 210.
[0055]

Even if actuators 240 are already any of well-known equipment or the equipment developed from now on, they should just be equipment which can impress the force of moving a bistability beam between stable states. Actuators 240 may be any of for example, a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator, or may be the combination of the arbitration. The concrete object to apply may be chosen based on the design consideration according to a predetermined application. For example, for a specific application, a thermal shock actuator or a zipper type electrostatic actuator may be convenient.

[0056]

As mentioned above, you may build the system based on the minute electronic mechanical system (MEMS) concerning this invention into a large system or a complex system. For example, as the outline was shown in drawing 4 , the optical switching system 300 contains 1 set of bistability beams 310. The bistability beam 310 is shown in drawing by the 1st stable state which presents a predetermined nonlinear configuration and which hardly receives stress.

[0057]

The input optical fiber 350 with which this system 300 is equipped further, and the output optical fiber 360 are arranged so that it may be connected with the waveguide 332,334 of a different steady state, respectively. The movable switching member 320 is located among the steady state waveguides 332 and 334, and is relatively movable to this steady state waveguide 332,334. The movable switching member 320 is arranged, and it constitutes so that it may move with the bistability beam 310. The movable switching member 320 may be equipped with the array of a waveguide 322 as shown in drawing 4 .

[0058]

In an activity, if Force F is impressed to the bistability beam 310 by the actuator (not shown), the bistability beam 310 will shift to the 2nd stable state (not shown) from the 1st stable state shown in drawing 4 . When the movable switching member 320 moves with the bistability beam 310, another waveguide 322 connects between the steady state waveguides 332 and 334. By this approach, the input of one lightwave signal of the input optical fiber 350 may be switched between the output optical fibers 360. Moreover, the waveguide 322 of the movable member 320 may be arranged and a lightwave signal may be switched by moving the movable member 320 to compensate for migration of the bistability beam 310 between the 1st stable state and the 2nd stable state. Furthermore, the waveguide 322 of the movable member 320 may be formed so that a lightwave signal may be attenuated.

[0059]

As shown in drawing 4 , the 2nd stable state may be changed by inserting a stopper 370. A stopper 370 is arranged so that one side of the bistability beam 310 may contact a stopper 370 before reaching the 2nd original stable state. If a stopper 370 is arranged in this way, in the 2nd stable state, bias of one side of the bistability beam 310 will be carried out to a stopper 370. The bistability beam 310 and the movable member 320 assist this condition so that it may result in the 2nd stable state correctly and certainly. As shown in drawing 4 , upheaval 372 may be formed in a stopper 370 and a part of bistability beam 310 in a contact condition and the static friction between stoppers 370 may be controlled.

[0060]

The graph illustrated to drawing 5 shows the variation rate of the beam to the force impressed in order to move a beam, and this force. The nonlinear configuration and geometry of a beam determine a actual curve.

[0061]

After moving from the 1st stable state, a beam passes an unstable equilibrium condition and shifts to the 2nd stable state of the beam which is in the stable equilibrium condition. The ideal point line showed the location of a stopper 370 in drawing 5 . As illustrated, the stopper is formed in the location of about 0.0185mm between an unstable equilibrium condition and the stable equilibrium condition applicable to the 2nd original stable state. Therefore, a beam will stop, before resulting in the stable equilibrium condition applicable to the 2nd original stable state. Bias of the beam is carried out to a stopper by the stability of the beam which tends toward this stable equilibrium condition.

[0062]

The system based on a bistability minute electronic mechanical system (MEMS) may be manufactured according to this invention by specifying a beam equipped with the predetermined nonlinear configuration corresponding to the 1st stable state of a beam with lithography. As a lithography technique, common knowledge or the lithography technique of the arbitration developed from now on may be used. With lithography, a property, for example, the configuration, geometry, etc. of a beam can be manufactured to accuracy.

[0063]

As mentioned above, the predetermined nonlinear configuration of a beam specifies the 1st stable state of this beam. The geometry of a beam specifies the 2nd stable state of this beam similarly. Therefore, according to the various operation gestalten of this invention, this manufacture approach is prescribing with lithography that a beam has further predetermined geometry, and contains the step which determines the 2nd stable state of a beam. Predetermined geometry may contain one or more, even if there are little predetermined die length, predetermined width of face, and predetermined curvature. It will be understood that height may be specified with the thickness of the ingredient layer by which a beam is created.

[0064]

Moreover, lithography may prescribe the predetermined geometry of a beam and other various properties of a beam may be specified. For example, the geometry of a beam may be specified so that at least the delivery distance of a beam and one side of a force curve may be specified.

[0065]

With the illustrated various operation gestalten, the actuator related with a bistability beam is formed using lithography. Similarly, the boundary condition of a bistability beam may also be formed using lithography technique. Moreover, although other same manufacturing technologies may be used, if the whole system is manufactured by the same technique, it is advantageous at the point which reduces the independent approach step, for example and can simplify a stroke.

[0066]

As mentioned above, a beam may carry out patterning of the beam within the device layer of a SOI wafer, and may specify it with lithography. While etching a device layer and the insulating layer between substrates selectively and releasing a beam, it leaves a part of insulating layer, and the support stop of the beam is carried out to a substrate. the amount of [which carries out the support stop of the beam] insulating layer specifies desired boundary condition on a beam -- as -- patterning -- and it etches.

[0067]

The example of the technique suitable for manufacture of the bistability beam within a device layer is indicated by the United States patent application 09th under simultaneous connection which uses the whole as it is for reference / No. 467,526, the 09th / No. 468,423, and the 09th / No. 468,141. Another suitable technique is indicated by the United States patent application 09th under simultaneous connection which uses the whole as it is for reference / No. 718,017.

[0068]

Generally, the step of a planar production process is used in detailed machining of a polish recon front face. This step is a step common to the (integrated-circuit IC) manufacture industry which manufactures a minute electronic machinery and micro mechanical equipment. Like a standard block assembler, the step which forms an alternative layer and carries out patterning with a photolithography technique on a substrate is included. An alternative layer contains polycrystalline silicon with low stress, and a sacrifice layer like the silicon dioxide for example, on a substrate. The beer etched through the sacrifice layer provides between polycrystalline silicon layers and a substrate with a support point. Patterning of the polycrystalline silicon layer is carried out, and the mechanical component of detailed machining equipment is formed. A mechanical component is formed for every layer in this way at a series of steps of a vacuum evaporationo process and a patterning process. A silicon-dioxide layer is removed by exposing after that to the alternative etching reagent which does not adhere to a polycrystalline silicon layer, for example, a hydrofluoric acid etc., (HF). The mechanical component formed in the

polycrystalline silicon layer is released by this, and actuation of a mechanical component is attained.
[0069]
Although this invention was explained referring to various operation gestalten, I will be understood if it is this contractor for various kinds of replacement, correction, and modification to be possible. Therefore, all of correction and modification are the things from which it does not swerve to the pneuma and the range of this invention and which are included by the range of this invention exchangeably.
[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram of the 1st operation gestalt of the minute electronic mechanical system (MEMS) containing the bistability beam concerning this invention.
[Drawing 2] It is the schematic diagram having shown the 1st operation gestalt of drawing 1 according to the 2nd stable state.
[Drawing 3] It is the schematic diagram of the 2nd operation gestalt of the minute electronic mechanical system (MEMS) containing the bistability beam concerning this invention, and an actuator.
[Drawing 4] It is the schematic diagram having shown the operation gestalt of the optical switching system containing the bistability beam concerning this invention according to the 1st stable state.
[Drawing 5] It is a graph showing the force curve of the operation gestalt of drawing 4 in the equilibrium condition by which the 2nd stable state was stabilized.
[Description of Notations]
100,200,300 The system and 101,201 based on a minute electronic mechanical system (MEMS) A substrate and 110,210,310 A bistability beam and 112,212 Boundary condition and 130 A steady state member and 240 An actuator and 300 An optical switching system and 320 A movable member and 332,334 A waveguide and 350 An input optical fiber and 360 An output optical fiber and 370 Stopper.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Field of the Invention]
This invention relates to the system based on a minute electronic mechanical system (MEMS) including the structure based on a minute electronic mechanical system (MEMS), and at least one bistability (bistable) structure. This invention relates to such a manufacture approach of structure and a system, and the actuation approach of a system based on a minute electronic mechanical system again.
[0002]

[Translation done.]

PRIOR ART

[Description of the Prior Art]
About the bistability beam, the application in the system based on a minute electronic mechanical system (MEMS) is known. Such a bistability beam is applied to a digital data storage, electronic formula switching, optical switching, etc.
[0003]
for example, the minute electronic mechanical-system publication magazine of the June, 2000 issuance of a good alignment micro mechanical bistability system by SAIFU (M. T.A.Saif) -- it is indicated by the 9th volume, No. 2, and 157-170-page "the good alignment bistability MEMS theory, an experiment ("On a Tunable Bistable MEMS-Theory andExperiment", Journal of Microelectromechanical Systems, Vol.9, No.2, pp.157-170, and June 2000) and nonpatent literature 1." This bistability system consists of long and slender micro mechanical beams attached in the actuator. A beam is exposed to the lateral force which manifests itself in the middle of manufacture, and residual stress. In order that an actuator may generate compressive force to the shaft orientations of a beam, a beam is buckled in a longitudinal direction and results in one condition of two equilibrium.
[0004]
Explanation [/ else / BAMBO / (Vangbo)] is indicated by the micro mechanical of publication, the micro engineering No. 8, 29-32 pages, and "a longitudinal direction symmetry bistability buckling beam ("A Lateral Symmetrically bistable buckled beam" J.Micromech.Micreng., 8 (1998)) and nonpatent literature 2" as another example of well-known beam structure in 1998. As it is in the publication, the snap stop of the longitudinal direction symmetry bistability beam is carried out to the equipment based on a minute electronic mechanical system (MEMS), and it is held in an orientation according to the spring force. This beam is equipped with the compression coat to which it is oxidized so that tensile stress may be guided, or it was fixed on the beam including the beam on which, as for beam structure, the release mold stood straight.
[0005]
The bistability electrostatic actuator which used the pneumatics joint or the water pressure joint is indicated by U.S. Pat. No. 6,168,395 (patent reference 1) given to KUENTSUA (Quenzer) etc. This bistability actuator contains the buckling thin film section driven with an enclosure electrode. A thin film operates by reaction as another thin film will be pushed up, if one thin film is lengthened in the lower part. Especially the bistability actuator was designed for the purpose of application on a micro bulb, and the electrode of a bow configuration is used for it.
[0006]
The electronic mechanical-cable-type switch of bistability by which detailed machining was carried out is indicated by U.S. Pat. No. 6,303,885 (patent reference 2) given to HICHIWA (Hichwa) etc. The switching device contained in this bistability switch is hung by two or more spring arms between the switch body sections. The spring arm is attached in the wall of the hollow body section of a central beam, and the wall of this spring arm and a beam in the air answers the motive power of an actuator, and deforms between stable states.

[0007]
[Patent reference 1]
U.S. Pat. No. 6,168,395 description
[Patent reference 2]
U.S. Pat. No. 6,303,885 description
[Nonpatent literature 1]
SAIFU, "On a Tunable Bistable MEMS-Theory and Experiment", Journal of Microelectromechanical Systems, Vol.9, No.2, pp.157-170, and June 2000
[Nonpatent literature 2]
"A lateral Symmetrically bistable buckled beam" J.Micromech.[besides BAMBO] Micreng., 8 (1998), pp.29-32
[0008]

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]
As mentioned above, either of the hollow **** which form inclusion stress, impression compressive force, or an additional spring is needed for a well-known bistability beam. However, if the actuator for impression compressive force is added, a design and manufacture of a system will become complicated. Moreover, if it includes in a beam and stress is created, since control of inclusion stress is difficult, manufacture will become difficult. Furthermore, if hollow **** is added, a design and manufacture will become still more complicated. Therefore, the object of this invention is to eliminate the conventional trouble and other conventional failures about a bistability beam which were mentioned above.
[0009]

[Translation done.]

MEANS

[Means for Solving the Problem]
The system and approach concerning this invention are the bistability beam by which detailed machining was carried out, and offer the bistability beam which has the 1st stable state from which this beam hardly receives stress.
[0010]
The system and approach concerning this invention improve the flexibility in the design of a bistability system independently again.
[0011]
The system and approach concerning this invention reduce the complexity in the design of a bistability system independently again.
[0012]
The system and approach concerning this invention improve the manufacturability of a bistability system independently again.
[0013]
The system and approach concerning this invention reduce a bistability system size and weight independently again.
[0014]
The system and approach concerning this invention reduce the manufacturing cost of a bistability system independently again.
[0015]
The system and approach concerning this invention offer independently the bistability actuation by which the engine performance has been improved again.
[0016]
The system and approach concerning this invention offer independently the bistability actuation by which at least one side of robustness and dependability has been improved again.
[0017]
The system and approach concerning this invention offer independently the bistability actuation by which effectiveness has been improved again.
[0018]
The system and approach concerning this invention offer independently the bistability beam whose rigidity outside a field improved again.
[0019]
The system and approach concerning this invention offer non-contact actuation of the bistability beam in one [at least] condition of a non-contact condition and a steady state independently again.
[0020]
The system and approach concerning this invention offer independently the switching which used the bistability system again.
[0021]

The system and approach concerning this invention offer the waveguide switch using bistability actuation independently again.
[0022]
The system and approach concerning this invention offer the attenuation using a bistability system independently again.
[0023]
The system and approach concerning this invention improve control of the 1st location of the bistability beam in the 1st stable state independently again.
[0024]
The system and approach concerning this invention improve control of the 2nd location of the bistability beam in the 2nd stable state independently again.
[0025]
The system and approach concerning this invention offer the bistability system containing a stopper independently again. This stopper contacts a bistability beam, when a bistability beam is in the condition near the 2nd stable state between the 1st stable state and the 2nd stable state.
[0026]
In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is the beam by which detailed machining was carried out, and contains the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. In various operation gestalten, a predetermined nonlinear configuration contains a simple curve. In other various operation gestalten, a predetermined nonlinear configuration contains a compound curve, for example, four almost same radii etc. Furthermore, in another operation gestalt, a predetermined nonlinear configuration includes a series of segments.
[0027]
In the illustrated various operation gestalten, a beam has at least one fixed boundary condition. In another, various operation gestalten, a beam has at least one bearing boundary condition. In another, various operation gestalten, a beam has at least one spring boundary condition. The beam may have the conditions which combined different boundary condition again.
[0028]
In the illustrated various operation gestalten, this system is further equipped with the stopper arranged between the 1st stable state of a beam, and the 2nd stable state. When a beam moves from the 1st stable state, this stopper may be arranged near the 2nd stable state of a beam so that bias may be carried out to this stopper.
[0029]
In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) The 1st stable state in which this beam hardly receives stress but which it is the beam by which detailed machining was carried out, and it presents a predetermined nonlinear configuration, The beam which has the 2nd stable state, the actuator formed in order to move this beam between the 1st stable state and the 2nd stable state, and the movable component which moves between the 1st location and the 2nd location according to migration between the 1st stable state of a beam and the 2nd stable state are included. Actuators may be any of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator. In this actuator, in the illustrated various operation gestalten, this actuator contains a zipper type electrostatic actuator (zippering electrostatic actuator) with another, various operation gestalten including a thermal shock actuator.
[0030]
In the example of the various operation gestalten about the system and approach of this invention, if the 1st force is impressed in the 1st direction, it will be the beam by which detailed machining was carried out, and the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration will shift to the 2nd stable state from the 1st stable

state. Impression of the 1st force may be constituted as impression of the force which used any one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and the magnetic actuators. Impression of the 1st force may consist of illustrated various operation gestalten as impression of the force which used the thermal shock actuator. Impression of the 1st force may consist of another, various operation gestalten as impression of the force which used the zipper type electrostatic actuator.

[0031]

With the illustrated various operation gestalten, if the 2nd force is impressed in the 2nd direction, a beam will shift to the 1st stable state from the 2nd stable state. Impression of the 2nd force may be constituted as impression of the force which used any one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and the magnetic actuators. Impression of the 2nd force may consist of another, various operation gestalten as impression of the force which used the thermal shock actuator or the zipper type electrostatic actuator.

[0032]

In the example of the various operation gestalten concerning the system and approach of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is manufactured by specifying with lithography the beam which has a predetermined nonlinear configuration corresponding to the 1st stable state of a beam. In the illustrated various operation gestalten, this manufacture approach contains the step which determines the 2nd stable state of a beam by prescribing with lithography that a beam becomes further specific geometry (geometry). In various operation gestalten, the step which prescribes with lithography that a beam has specific geometry contains the step which specifies a beam with lithography so that it may have at least one of specific die length, specific width of face, specific height, and the specific curvatures. With various operation gestalten, the height of a beam is defined as the height of a beam becoming larger than the width of face of a beam, and the bucklings outside the field of a potential beam are reduced.

[0033]

In the illustrated various operation gestalten, this manufacture approach is prescribing with lithography that a beam has further specific geometry, and contains the step which determines the delivery distance of the beam between the 1st stable state and the 2nd stable state. With various operation gestalten, the step which prescribes with lithography that a beam has specific geometry contains the step which prescribes with lithography that a beam has at least one of specific die length, specific width of face, specific height, and the specific curvatures.

[0034]

In the illustrated various operation gestalten, this manufacture approach is prescribing with lithography that a beam has further specific geometry, and contains the step which determines the force curve of the beam between the 1st stable state and the 2nd stable state. In various operation gestalten, the step which prescribes with lithography that a beam has specific geometry contains the step which prescribes with lithography that a beam has at least one of specific die length, specific width of face, specific height, and the specific curvatures.

[0035]

In the illustrated various operation gestalten, this manufacture approach contains further the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator. With various operation gestalten, the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator contains the step which forms a thermal shock actuator. With other various operation gestalten, the step which adjoins a beam and forms at least one of a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator contains the step which forms a zipper type electrostatic actuator.

[0036]

In the illustrated various operation gestalten, this manufacture approach contains further the step which forms the fixed boundary condition of at least one beam. In another, various operation gestalten, this manufacture approach contains further the step which forms the bearing boundary condition of at least

one beam. In other various operation gestalten, this manufacture approach contains further the step which forms the spring boundary condition of at least one beam. This manufacture approach may also contain the step which forms the boundary condition of the beam which combined different boundary condition further.

[0037]

In the illustrated various operation gestalten, the manufacture step which defines a beam as a lithography technical target contains the step which carries out patterning of the beam to the device layer of a SOI (silicon-on-insulator) wafer. This manufacture approach contains the step which leaves an insulating layer selectively and carries out the support stop of the beam to a substrate while it etches a device layer and the insulating layer between substrates selectively and releases a beam further.

[0038]

the systems based on a minute electronic mechanical system (MEMS) be the input section , the output section , the movable component that connect between the I/O sections , and the beam detailed machining be carried out by the beam , and contain the beam which have the 1st stable state in which this beam hardly receive stress but , which it present a predetermined nonlinear configuration , and the 2nd stable state in the example of the various operation gestalten concerning the system and the approach of this invention . In the illustrated various operation gestalten, this system is an optical system equipped with the optical I/O section. In illustrated another operation gestalt, this system is the electronic system equipped with the electronic formula I/O section. Furthermore, in another operation gestalt, this system is a hydraulic system equipped with the fluid I/O section. In the illustrated various operation gestalten, this system contains a data storage system. In illustrated another operation gestalt, this system contains a switching system.

[0039]

The property and advantage of this invention which were mentioned above will become clear from detailed explanation of the following about the system concerning this invention, and the various operation gestalten of an approach.

[0040]

[Embodiment of the Invention]

The various operation gestalten about the system and approach of this invention are explained referring to an attached drawing.

[0041]

Although this invention is explained referring to an optical switching system, it will be understood that this invention is not limited to such a system. The system based on the minute electronic mechanical system (MEMS) using a bistable state is set as the object of this invention. The following explanation is to show the description of this invention, and does not limit this invention to the indicated specific operation gestalt.

[0042]

The system and approach concerning this invention offer the system based on a bistability minute electronic mechanical system (MEMS). In the various operation gestalten of this invention, the system based on a bistability minute electronic mechanical system (MEMS) is the beam by which detailed machining was carried out, and contains the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. The system based on the bistability minute electronic mechanical system (MEMS) concerning this invention offers at least one side of the bistability actuation by which the engine performance has been improved, and the bistability actuation by which effectiveness has been improved while offering improvement in the flexibility in a design, an improvement of manufacturability, the cutback of size and weight, and the cutback of a manufacturing cost.

[0043]

In the illustrated various operation gestalten, a predetermined nonlinear configuration contains a simple curve. In another, various operation gestalten, a predetermined nonlinear configuration contains a compound curve. A compound curve may also contain four for example almost same radii. Furthermore,

in another operation gestalt, a predetermined nonlinear configuration includes a series of segments. A predetermined nonlinear configuration specifies the 1st stable state of a beam.

[0044]

In the illustrated various operation gestalten, the system based on a bistability minute electronic mechanical system (MEMS) contains the step which prescribes with lithography that a beam becomes a predetermined nonlinear configuration corresponding to the 1st stable state of a beam. In the illustrated various operation gestalten, the 2nd stable state of a beam is searched for by prescribing with lithography that a beam has at least one of predetermined geometry, for example, predetermined die length, width of face, and the curvatures. Furthermore, another property of a beam may be determined by prescribing with lithography that a beam becomes specific geometry. Lithography offers the accuracy and the controllable production process which do not generate stress.

[0045]

In the illustrated various operation gestalten, the method of specifying a beam with lithography contains the step which carries out patterning of the beam to the device layer of a SOI (silicon-on-insulator) wafer. This manufacture approach leaves a part of insulating layer, and contains the step which carries out the support stop of the beam to a substrate while it etches a device layer and the insulating layer between substrates selectively and releases a beam further. Since most device layers are layers which do not receive stress, they can eliminate unnecessary stress out of a beam.

[0046]

The system and approach concerning this invention offer bistability actuation again. In the illustrated various operation gestalten, if the 1st force is impressed in the 1st direction, it will be the beam by which detailed machining was carried out, and the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration will shift to the 2nd stable state from the 1st stable state. In the illustrated various operation gestalten, if the 2nd force is impressed in the 2nd direction, a beam will shift to the 1st stable state from the 2nd stable state.

[0047]

At least one side of the beam concerning this invention and bistability actuation may be applied to various kinds of applications, and may form some large systems. For example, the systems based on a minute electronic mechanical system (MEMS) are the input section, the output section, the movable component that connects between the I/O sections, and the beam by which detailed machining was carried out, and contain the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. Furthermore, these systems may be any of an optical system, electronic system, or a hydraulic system. Moreover, this system may be a data storage system or a switching system.

[0048]

According to the various operation gestalten of illustrated this invention, a detailed machining technique and the manufacturing technology based on other micro mechanical systems are the beams by which detailed machining was carried out, and are used for processing the beam which has the 1st stable state in which this beam hardly receives stress but, which it presents a predetermined nonlinear configuration, and the 2nd stable state. Such a processing technique progressed comparatively compared with other possible techniques, and brings about a more reliable result and more advanced flexibility. With the illustrated various operation gestalten, a bistability beam is manufactured using surface micro-processing technique, for example, the lithography mentioned above.

[0049]

The schematic diagram of the system 100 based on the minute electronic mechanical system (MEMS) concerning the 1st operation gestalt of this invention is shown in drawing 1 . This system 100 contains 1 set of bistability beams 110 shown in drawing according to the 1st stable state. Although 1 set of bistability beams are illustrated, it could be understood that a single bistability beam may be used. If two or more bistability beams are adopted, since a beam will function in cooperation, at least one of the engine performance, dependability, and the precision improves. The support stop of the bistability beam 110 is carried out to a substrate 101 using the boundary condition which combined the suitable boundary

condition 112, for example, fixed boundary condition, bearing boundary condition, spring boundary condition, or different boundary condition. In the 1st stable state, the bistability beam 110 becomes a predetermined nonlinear configuration, and it is manufactured so that the condition of hardly receiving stress may be attained.

[0050]

The movable member 120, for example, a waveguide, an optical fiber, etc. may be prepared, and you may constitute so that the movable member 120 may move with the bistability beam 110. As shown in drawing 1 , the steady state member 130 corresponding to a waveguide, an optical fiber, etc. is fixed to a substrate 101.

[0051]

The schematic diagram of the 1st operation gestalt is shown in drawing 2 . The bistability beam 110 in the 2nd stable state was shown in drawing. As illustrated, the movable member 120 moves to the 2nd stable state from the 1st stable state with the bistability beam 110, and is aligned or connected with the steady state member 130. If Force F is impressed to the bistability beam 110 as shown in drawing 1 and drawing 2 , the bistability beam 110 will move between the 1st stable state and the 2nd stable state.

[0052]

The schematic diagram showed the bistability beam 110 to drawing 1 and drawing 2 . Although a suitable configuration including a simple curve, a compound curve, a series of segments, etc. may be used for the predetermined nonlinear configuration of a beam, it is not limited to these configurations. Thus, a predetermined nonlinear configuration is good in the configuration of arbitration where the 1st stable state can be specified.

[0053]

The schematic diagram of the system 200 based on the minute electronic mechanical system (MEMS) concerning the 2nd operation gestalt of this invention is shown in drawing 3 . This system 200 contains 1 set of bistability beams 210 illustrated by the 1st stable state, and at least one actuator 240. The support stop of the bistability beam 210 is carried out to a substrate 201 using the suitable boundary condition 212.

[0054]

The movable member 220 is arranged, and it constitutes so that the movable member 220 may move with the bistability beam 210. The movable member 220 shifts to the 2nd stable state from the 1st stable state with a bistability beam with an actuator 240. According to the force which an actuator 240 impresses to the bistability beam 210, the bistability beam 210 moves between the 1st stable state and the 2nd stable state. About this force, even if you may impress directly or indirectly and contact on the bistability beam 210 realizes, you may realize, without contacting the bistability beam 210.

[0055]

Even if actuators 240 are already any of well-known equipment or the equipment developed from now on, they should just be equipment which can impress the force of moving a bistability beam between stable states. Actuators 240 may be any of for example, a heat actuator, an electrostatic actuator, an electrostrictive actuator, and a magnetic actuator, or may be the combination of the arbitration. The concrete object to apply may be chosen based on the design consideration according to a predetermined application. For example, for a specific application, a thermal shock actuator or a zipper type electrostatic actuator may be convenient.

[0056]

As mentioned above, you may build the system based on the minute electronic mechanical system (MEMS) concerning this invention into a large system or a complex system. For example, as the outline was shown in drawing 4 , the optical switching system 300 contains 1 set of bistability beams 310. The bistability beam 310 is shown in drawing by the 1st stable state which presents a predetermined nonlinear configuration and which hardly receives stress.

[0057]

The input optical fiber 350 with which this system 300 is equipped further, and the output optical fiber 360 are arranged so that it may be connected with the waveguide 332,334 of a different steady state,

respectively. The movable switching member 320 is located among the steady state waveguides 332 and 334, and is relatively movable to this steady state waveguide 332,334. The movable switching member 320 is arranged, and it constitutes so that it may move with the bistability beam 310. The movable switching member 320 may be equipped with the array of a waveguide 322 as shown in drawing 4 .

[0058]

In an activity, if Force F is impressed to the bistability beam 310 by the actuator (not shown), the bistability beam 310 will shift to the 2nd stable state (not shown) from the 1st stable state shown in drawing 4 . When the movable switching member 320 moves with the bistability beam 310, another waveguide 322 connects between the steady state waveguides 332 and 334. By this approach, the input of one lightwave signal of the input optical fiber 350 may be switched between the output optical fibers 360. Moreover, the waveguide 322 of the movable member 320 may be arranged and a lightwave signal may be switched by moving the movable member 320 to compensate for migration of the bistability beam 310 between the 1st stable state and the 2nd stable state. Furthermore, the waveguide 322 of the movable member 320 may be formed so that a lightwave signal may be attenuated.

[0059]

As shown in drawing 4 , the 2nd stable state may be changed by inserting a stopper 370. A stopper 370 is arranged so that one side of the bistability beam 310 may contact a stopper 370 before reaching the 2nd original stable state. If a stopper 370 is arranged in this way, in the 2nd stable state, bias of one side of the bistability beam 310 will be carried out to a stopper 370. The bistability beam 310 and the movable member 320 assist this condition so that it may result in the 2nd stable state correctly and certainly. As shown in drawing 4 , upheaval 372 may be formed in a stopper 370 and a part of bistability beam 310 in a contact condition and the static friction between stoppers 370 may be controlled.

[0060]

The graph illustrated to drawing 5 shows the variation rate of the beam to the force impressed in order to move a beam, and this force. The nonlinear configuration and geometry of a beam determine a actual curve.

[0061]

After moving from the 1st stable state, a beam passes an unstable equilibrium condition and shifts to the 2nd stable state of the beam which is in the stable equilibrium condition. The ideal point line showed the location of a stopper 370 in drawing 5 . As illustrated, the stopper is formed in the location of about 0.0185mm between an unstable equilibrium condition and the stable equilibrium condition applicable to the 2nd original stable state. Therefore, a beam will stop, before resulting in the stable equilibrium condition applicable to the 2nd original stable state. Bias of the beam is carried out to a stopper by the stability of the beam which tends toward this stable equilibrium condition.

[0062]

The system based on a bistability minute electronic mechanical system (MEMS) may be manufactured according to this invention by specifying a beam equipped with the predetermined nonlinear configuration corresponding to the 1st stable state of a beam with lithography. As a lithography technique, common knowledge or the lithography technique of the arbitration developed from now on may be used. With lithography, a property, for example, the configuration, geometry, etc. of a beam can be manufactured to accuracy.

[0063]

As mentioned above, the predetermined nonlinear configuration of a beam specifies the 1st stable state of this beam. The geometry of a beam specifies the 2nd stable state of this beam similarly. Therefore, according to the various operation gestalten of this invention, this manufacture approach is prescribing with lithography that a beam has further predetermined geometry, and contains the step which determines the 2nd stable state of a beam. Predetermined geometry may contain one or more, even if there are little predetermined die length, predetermined width of face, and predetermined curvature. It will be understood that height may be specified with the thickness of the ingredient layer by which a beam is created.

[0064]

Moreover, lithography may prescribe the predetermined geometry of a beam and other various properties of a beam may be specified. For example, the geometry of a beam may be specified so that at least the delivery distance of a beam and one side of a force curve may be specified.
[0065]
With the illustrated various operation gestalten, the actuator related with a bistability beam is formed using lithography. Similarly, the boundary condition of a bistability beam may also be formed using lithography technique. Moreover, although other same manufacturing technologies may be used, if the whole system is manufactured by the same technique, it is advantageous at the point which reduces the independent approach step, for example and can simplify a stroke.
[0066]
As mentioned above, a beam may carry out patterning of the beam within the device layer of a SOI wafer, and may specify it with lithography. While etching a device layer and the insulating layer between substrates selectively and releasing a beam, it leaves a part of insulating layer, and the support stop of the beam is carried out to a substrate. the amount of [which carries out the support stop of the beam] insulating layer specifies desired boundary condition on a beam -- as -- patterning -- and it etches.
[0067]
The example of the technique suitable for manufacture of the bistability beam within a device layer is indicated by the United States patent application 09th under simultaneous connection which uses the whole as it is for reference / No. 467,526, the 09th / No. 468,423, and the 09th / No. 468,141. Another suitable technique is indicated by the United States patent application 09th under simultaneous connection which uses the whole as it is for reference / No. 718,017.
[0068]
Generally, the step of a planar production process is used in detailed machining of a polish recon front face. This step is a step common to the (integrated-circuit IC) manufacture industry which manufactures a minute electronic machinery and micro mechanical equipment. Like a standard block assembler, the step which forms an alternative layer and carries out patterning with a photolithography technique on a substrate is included. An alternative layer contains polycrystalline silicon with low stress, and a sacrifice layer like the silicon dioxide for example, on a substrate. The beer etched through the sacrifice layer provides between polycrystalline silicon layers and a substrate with a support point. Patterning of the polycrystalline silicon layer is carried out, and the mechanical component of detailed machining equipment is formed. A mechanical component is formed for every layer in this way at a series of steps of a vacuum evaporationo process and a patterning process. A silicon-dioxide layer is removed by exposing after that to the alternative etching reagent which does not adhere to a polycrystalline silicon layer, for example, a hydrofluoric acid etc., (HF). The mechanical component formed in the polycrystalline silicon layer is released by this, and actuation of a mechanical component is attained.
[0069]
Although this invention was explained referring to various operation gestalten, I will be understood if it is this contractor for various kinds of replacement, correction, and modification to be possible. Therefore, all of correction and modification are the things from which it does not swerve to the pneuma and the range of this invention and which are included by the range of this invention exchangeably.

[Translation done.]

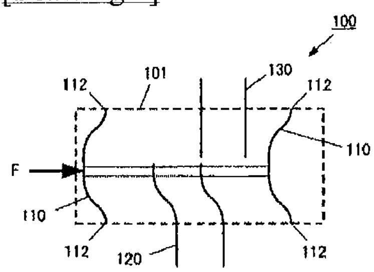
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram of the 1st operation gestalt of the minute electronic mechanical system (MEMS) containing the bistability beam concerning this invention.
[Drawing 2] It is the schematic diagram having shown the 1st operation gestalt of drawing 1 according to the 2nd stable state.
[Drawing 3] It is the schematic diagram of the 2nd operation gestalt of the minute electronic mechanical system (MEMS) containing the bistability beam concerning this invention, and an actuator.
[Drawing 4] It is the schematic diagram having shown the operation gestalt of the optical switching system containing the bistability beam concerning this invention according to the 1st stable state.
[Drawing 5] It is a graph showing the force curve of the operation gestalt of drawing 4 in the equilibrium condition by which the 2nd stable state was stabilized.
[Description of Notations]
100,200,300 The system and 101,201 based on a minute electronic mechanical system (MEMS) A substrate and 110,210,310 A bistability beam and 112,212 Boundary condition and 130 A steady state member and 240 An actuator and 300 An optical switching system and 320 A movable member and 332,334 A waveguide and 350 An input optical fiber and 360 An output optical fiber and 370 Stopper.

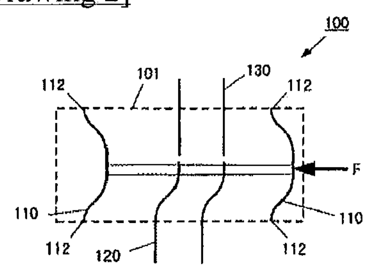
[Translation done.]

DRAWINGS

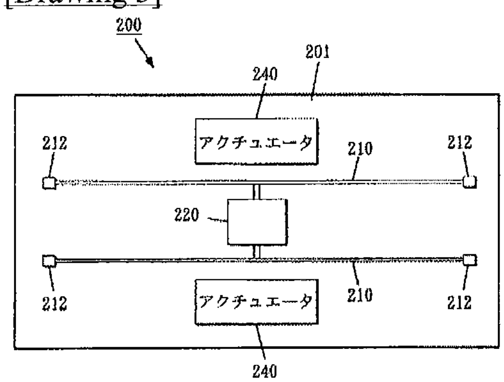
[Drawing 1]



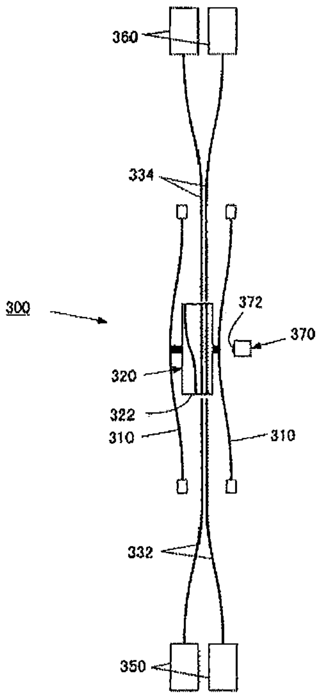
[Drawing 2]



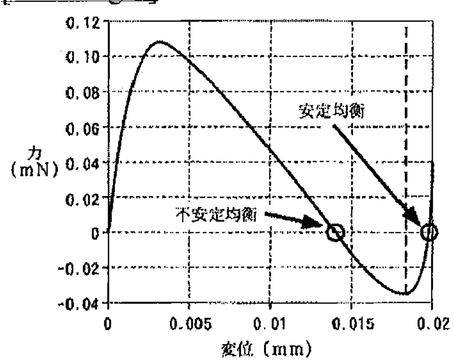
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Translation done.]